ARABIAN NEMATODES.

By N. A. Cobb.

In the winter of 1888-9, I collected, among other things, on the coast of Arabia, about two hundred marine Nematodes, an examination of which discovers seven specific forms. The marine Nematodes hitherto studied, those of Carter excepted, have been taken from European branches of the Atlantic Ocean, *i.e.*, the Baltic, North and Mediterranean Seas. It is therefore of interest to find that all the species in my Arabian collection can be referred to known genera inhabiting Atlantic waters. I afterwards observed some of these forms living on coasts of the Southern and of the Pacific Oceans, as well as on other coasts of the Indian Ocean. The geographical range is therefore roughly indicated. Various structural facts here recorded will, I think, be found of interest by those familiar with the Nematode anatomy.

Methods.

Nematodes are to be sought (1) among marine and fresh-water algæ, (2) in sand and mud at the bottom of water not too stagnant, (3) in moist earth especially about the roots of plants, (4) on and in the higher plants, and (5) in the greatest variety of animals, where either as facultative or obligate parasites they are often the cause of specific diseases of the most serious kind.

In the hope of stimulating yet closer examination into the structure and life-histories of the free-living Nematodes by showing how easily and in what super-abundance the necessary material may be obtained, I detail here the methods I have found useful. These methods apply to a host of other minute organisms, all less frequently studied than they would be if better ways of securing and investigating them were known.

The principle underlying my process of collecting free-living Nematodes is one long practised by prospectors. I prospect for Nematodes in the same way that a miner prospects for gold. Suppose, for instance, that the sand of some beach or fresh-water stream is inhabited, as often happens, by Nematodes and other minute organisms. To quickly isolate these little animals in great numbers the collector has only to profit by the fact, that in standing water sand sinks at once, while small organisms sink rather slowly. Put half a pound of the sand with a pint of water into a dish of the form and size of an ordinary one-quart fruit-tin. Having a second beaker or fruit-tin at hand empty, pour the water and sand rapidly back and forth until the water is well roiled—then suddenly stop. The sand at once sinks to the bottom of the dish, but the organisms remain for a few seconds partially suspended. The instant the sand reaches the bottom of the dish, pour the supernatant fluid containing the organisms into a third dish and there let it stand until clear, when the sediment of organisms may be obtained in a very satisfactory state by decanting the clear water.

To collect from mud, reverse the process; that is to say, after agitating the mud and water allow the roily mixture to stand until the *organisms* have settled, then pour away the muddy water. Repeat this process until the desired result is obtained.

In collecting from algæ it will be found best to use a large shallow dish. Place the algæ in the dish with an abundance of water. To separate the Nematodes from the algæ, stir the latter briskly about in the water, squeezing them often, and finally wring them dry and throw them away. Allow the washings to stand for a quarter of an hour, and then decant. Put the sediment into deep dishes, and treat as directed for sand or mud, or both, as may be necessary.

To collect from culms of grasses or sedges or from other land plants, cut a quantity of the plants and put them into a wash-tub and cover them with water. Allow them to soak an hour, then proceed as with algæ.

The sediment obtained by any of the above operations consists of Nematodes and numerous other small organisms, along with dead matter of about the same specific gravity. This sediment is placed, a teaspoonful at a time, in a shallow glass dish three to four inches in diameter, containing about half an inch of water, and the Nematodes are captured by transmitted light under a magnifying glass with a fine-pointed medicine-dropper. I make my own medicine-droppers, as I find the boughten ones have points too large for my purposes.

If the animals are to be studied in a living state, they may be rendered motionless by adding a little chloral hydrate solution to the water in which they are to be examined. The action of the chloral hydrate is simply narcotic. The animals recover, and may afterwards be killed and preserved by any process desired. I believe this method is due to Davaine. If glycerine preparations are to be made, kill with osmic acid of $\frac{1}{1000}$ to $\frac{1}{100}$ per cent. Allow the worms to remain in the acid until their original whiteness or transparency becomes a trifle clouded. The first slight cloudiness is the signal for transferring to water and starting the preparations on their road to glycerine by way of the differentiator. The results are good, especially if warm but weak osmic acid is used.

For the very finest histological as well as coarser anatomical studies I have devised the following method, which gives far better results than any other with which I am acquainted :—On capturing a worm with the medicine-dropper, I eject it forcibly into 20 cc. of concentrated solution of corrosive sublimate, kept at 50°-60° Centigrade by floating it in a porcelain dish on the surface of hot water. If the sublimate solution is much hotter than 60° the bodies of some species burst. The worms should remain in the hot sublimate solution at least an hour, better longer. When a sufficient number of worms has been captured, pour the sublimate solution, worms and all, into a flat glass dish placed on a black background, and pick out the worms with the aid of a magnifying glass and a fine-pointed medicine-dropper, and put them into the prepared object-box of a differentiator. Stain and

bring into balsam by means of the differentiator. Most of the smaller species stain readily in borax carmine, which is one of the best of stains for this work. *Oxyuris vermicularis* (adults, not the young) and a number of other parasitic species, however, do not stain in borax carmine. Mayer's carmine rarely fails to stain these exceptional species. Overstaining is corrected by adding hydrochloric acid to the proper differentiator fluids. *I can recommend this method very highly, not only for Anguillulidæ, but also for numerous other groups of the smaller animals and plants.*

Formula.

I intend to describe in a series of papers, of which this is one of the first, a large number of hitherto unknown Nematodes. In order to bring the characterizations into small compass, and thus gain space for the fuller discussion of such morphological, physiological, and pathological problems as may present themselves, I shall make use of a new formula which expresses briefly and accurately the necessary measurements.

Inasmuch as this formula will occur once or twice in the description of each species, and be made to bear such a large share of the burden of characterization as to become, in a systematic sense, a prime factor in the work, it merits at the outset a full elucidation.

Since the middle of the present century nematelminthologists have shown an ever-increasing regard to absolute and relative dimensions. Dujardin (1846) gave the length, the ratio between the length and breadth, and occasionally other dimensions, such as the length of the tail and the position of the vulva. No one did more than this until Eberth and Bastian, working simultaneously on the Anguillulidæ, saw the necessity for further particularization. These two investigators, the one in Germany, and especially the other in England, laid firm the foundation of the important superstructure afterwards raised by Bütschli, Marion, De Man, Von Linstow and others. The appearance of their works (Eb. 1863, Bast. 1866) marks an era in the history of our knowledge of the group of which they treated. Their texts were accompanied by

accurate and well executed figures of both extremities of each worm described. The dimensions given, based sometimes it is true on too few or otherwise too imperfect measurements, related to the length, breadth, position of the vulva, depth of the buccal cavity, and the fraction of the entire length occupied by the tail and œsophagus respectively. To these Bastian added the dimensions of the spicula and striæ. The English author, making the inch his unit of length, contented himself with giving a categorical list of the measurements made. Thus, taking a species at random, *Enoplus pigmentosus* was entered as $\frac{1}{3} \times {}_1\frac{1}{0\,0}$; teeth, $\frac{1}{6\,6\,6}$; œsophagus, about $\frac{1}{7}$ (*i.e.*, of the total length); tail, $\frac{1}{1\,6\,0}$. This is manifestly not very convenient for the reader. The German author, making the millimeter his unit of length, followed the same plan as his English contemporary but gave fewer measurements, trusting no doubt that the exquisite figures accompanying his text would supply all necessary information concerning details. Bütschli, the renowned Heidelberg naturalist, followed (1873-4) the plan adopted by Bastian and Eberth, but brought to his aid a greater amount of pictorial art. His illustrations are full length portraits, accompanied by figures on a larger scale, the latter illustrating the details of the head, tail, &c. Marion (1873) furnished no new ideas to the nomenclaturist. De Man, however, has introduced decided improvements in nomenclature. Realizing the necessity for exactitude and completeness in the matter of measurements, this author, who has described a greater number of new forms than any of his predecessors in the same field, and added also very essentially to our knowledge of the Nematode anatomy in general, has adopted a series of ratios by which a considerable number of measurements are expressed very concisely. These ratios he represents by the Greek letters α, β, γ,—his α being the ratio of the length to the median (greatest) diameter, β the ratio of the total length to the length of the œsophagus, and γ the ratio of the total length to the length of the tail. Thus, after having given the absolute length, he is enabled to give three remaining dimensions by means of such an expression as the following: $\alpha = 45$, $\beta = 5$, $\gamma = 8$.

The formula which I now propose points out, by means of eleven numbers, eleven dimensions, and serves at the same time to indicate the sex from which the measurements were taken, as well as the general form and size of the sexual organs. The following are my formulæ for a species of Oncholaimus :—

Female.						Male.					
1·	8·2	17·2	52·	93·3	1·77	·8	8·	16·6	M	94·1	1·85
·9	1·5	1·6	1·7	·8		·8	1·3	1·4	14	·8	

The formula for the male is distinguished from that of the female by the use of the letter M, for reasons presently to be stated. In order to exhibit in as graphic manner as possible the nature of this new formula, I have desired the printer to set up the above formula for the female in special type as follows :—

	Pharynx.	Nerve-ring.	Base of Neck.	Vulva.	Anus.	
Lengths	1·	8·2	17·3	52·	93·3	1·77 mm.
Diameters	·9	1·5	1·6	1·7	·8	
	Pharynx.	Nerve-ring.	Base of Neck.	Vulva.	Anus.	

The numbers above the horizontal line relate to longitudinal measurements, while those below it relate to diametral measurements. The first number above the line (1·) represents the distance from the anterior extremity of the animal to the bottom of the pharynx or buccal cavity. The first number below the line (·9) represents the length of the body-diameter which passes through the base of the pharynx. The second number above the line (8·2) represents the distance from the anterior extremity of the animal to the centre of the nerve-ring; and the number directly below (1·5) represents the length of the corresponding diameter, *i.e.*, the body-diameter passing through the nerve-ring. The third pair of numbers (17·3 and 1·6) represent measurements relating to the posterior end of the œsophagus or base of the neck. In other words, 17·3 is the distance from the anterior extremity of the animal to the posterior end of the œsophagus, or is the length of the neck including the head; and 1·6 is the diameter of the body at the point where the œsophagus joins the intestine, *i.e.*, where the neck joins the body. Finally, 52 and 93·3 are the distances from the anterior extremity to the vulva and anus respectively,

and 1·7 and ·8 are the lengths of the corresponding diameters. It will be seen that the different dimensions are taken up in the formula in a natural order. Reading the formula from left to right reads off the dimensions of the animal from head to tail. Now comes the peculiarity of the formula: *The unit of measurement is not absolute but relative*, is, in fact, nothing else than the hundredth part of the length of the worm itself. In other words, the measurements are expressed as percentages of the total length of the animal. Thus, the first measurement (1·) indicates that the depth, *i.e.*, the length, of the pharynx is equal to 1 per cent. of the total length of the body. So the measurements for the base of the neck indicate that the length of the neck is equal to 17·3 per cent. of the body-length, while the length of the diameter at the base of the neck is equal to 1·6 per cent of the body-length. The absolute length of the animal expressed in millimeters is placed at the right. In the present case that length is 1·77 millimeters.* In the formula for males the measurements relating to the vulva of the female are replaced by measurements relating to the middle of the body. The fourth number above the line becomes, therefore, always 50, and is indicated by M. The number below M gives the diameter of the male at the middle. In other respects the formula for the male is similar to that for the female.

Unless otherwise stated all measurements must be understood to be taken from adult specimens as they appear in profile.

By the use of certain signs the fourth term above the line may be made to convey an idea of the form and size, as well as the

* Dividing 1·77 millimeters by one hundred, we obtain the unit of length used in the remainder of the formula. The result is ·0177 millimeters. If it is desired to obtain the absolute length of the pharynx, neck, or other part, multiply the proper measurement by this coefficient (·0177). This gives for the absolute length of the pharynx $·0177 \times 1 = ·0177$ millimeters, and for the length of the neck $·0877 \times 17·3 = ·3$ millimeters. It is well known, however, that absolute dimensions, in such a case, are of very little consequence, while relative dimensions are of the greatest importance, and the great advantage possessed by such a formula as that now under consideration is that relative dimensions are made prominent.

position, of the sexual organs. The female genital organs lie either on one or both sides of the vulva, and the branches are either straight or reflexed. Letting a hyphen represent a straight, and a quotation mark a reflexed branch, we have—

-52·1- indicates two straight branches, one on either side of the vulva.
'52·1' indicates two reflexed branches, one on either side of the vulva.
52·1- indicates one straight branch behind the vulva.
52·1' indicates one reflexed branch behind the vulva.
-52·1 indicates one straight branch in front of the vulva.
'52·1 indicates one reflexed branch in front of the vulva.

In case of the male—

-M- indicates two straight testicles extending in opposite directions.
-M indicates one straight testicle extending forwards.
M- indicates one straight testicle extending backwards.
M' indicates one reflexed testicle extending backwards.
'M indicates one reflexed testicle extending forwards.

It should be borne in mind that the marks in the case of the male refer exclusively to the form and position of the testicle proper, that is to say, that portion of the generative apparatus beyond the *vas deferens*. When two testicles are present their limits are easily defined, for the point where they join marks the beginning of the *vas deferens*. When but a single testicle exists it is marked off from the *vas deferens* by a constriction in the same way that the *vas deferens* is marked off from the *ductus ejaculatorius*.

The percentage of the body occupied by the sexual organs is indicated by superior or reference figures placed at the right of and above the fourth term. Thus '50'^{30} represents a female sexual apparatus whose vulva is central, and whose symmetrically reflexed branches occupy 30% of the length of the body.

One may quickly familiarize himself with this new formula by imagining that the horizontal line represents the animal under consideration, and that the dimensions are written alongside, opposite the proper parts,—that is, opposite the base of the pharynx, the nerve-ring, the base of the neck, the vulva, and the anus.

Being already familiar with the use of this formula, I am not a proper judge of the difficulties that would occur to a novice in its use. To me the most obvious difficulty is that of having always to consider the anus with reference to its distance from the anterior instead of, as is usual, from the posterior extremity, a difficulty which should disappear with a little practice. It is much easier to enumerate what seem to me the advantages of the formula.

(1.) The position of each number indicates the dimension to which it refers. The formula is thus brief, yet concise.

(2.) The position of the nerve-ring is indicated. In properly prepared specimens the position of the nerve-ring is clearly to be seen, so there is no longer any reason why the position of so important an organ should not be entered among the characteristics. In order to see at once the relative position occupied by the nerve-ring, comparison should be made between the second and third numbers above the line. It will be thus seen that in the species whose formula has been given, the ring is situated a little in front of the middle of the neck.

(3.) A glance along the lower line of the formula reveals at once the general form of the body. The worm whose formula has been given has a somewhat cylindrical body. The portion of the neck in front of the nerve-ring tapers considerably. The body also tapers considerably in front of the anus. This latter is patent from comparison of ·8 with 52·1. The vulva is central, which means that the sexual organs are probably double and symmetrical. Therefore the body would not be likely to diminish much in size in the immediate vicinity of the vulva. Hence the decrease in size (1·7 to ·8) must take place considerably behind the vulva, and therefore near the anus. In very plump worms the largest of the numbers below the line may rise as high as 10, in slender ones become less than unity.

(4.) By averaging the specific formulæ of a genus, we may obtain a generic formula. During phylogenetic and systematic studies the specific and generic formulæ greatly facilitate the necessary comparisons.

I hope by the aid of this new formula to be able to describe such species as belong to already well known genera, even without the aid of illustrations, so accurately as to leave little to be desired, and yet so briefly as to leave space for the full discussion of biological and economic problems.

Oncholaimus, Duj.

O. orientalis, Cobb.* $\frac{1{\cdot}6\ \ 8{\cdot}\ \ 17{\cdot}3\ \ 76{\cdot}4\ \ 94{\cdot}9}{1{\cdot}3\ \ 1{\cdot}8\ \ 2{\cdot}\ \ 2{\cdot}1\ \ 1{\cdot}2}$ 3·9 mm. Submedian hairs, so inconspicuous as to escape observation under ordinary magnification, may be found throughout the length of the body by use of the highest powers. The cuticula is not striated. To the convex-conoid anterior half of the neck succeeds a somewhat compressed head, which is rounded in front, and bears, well forward, a row of six slender setæ. The six large and thin lips form a kind of dome over the pharyngeal cavity, their free extremities appearing, however, never to meet. Each lip therefore approximates in shape to an isosceles spherical triangle. Chitinous thickenings strengthen the margins of each lip, and from the apex a movable incurved hair or flap projects forward and inward. About a dozen minute nuclei occur near each point where two adjacent lips join each other at the base,—nuclei very much smaller than those found elsewhere in the body, being in fact scarcely larger than the oesophageal pigment granules. Doubtless these nuclei appertain to the muscles and nerves which govern the lips. I saw no papillæ around the mouth. The nearly circular lateral organs, one-fifth as wide as the head, are most conspicuous when the animal is seen from above or below; they then appear like two oblique lateral pockets opposite to or a little behind the middle of the pharynx. There are no eye spots, but granules of brownish pigment, arranged in radial lines, are abundant in the anterior half of the œsophagus,

* Cobb, "The Differentiator." Sydney, 1889.

especially at the base of the pharynx. This last is two-thirds as wide as deep, and bears a small dorsal tooth behind the middle, and two large sub-equal or equal submedian teeth, each of which extends about three-fourths the distance to the lips and there ends (opposite the bases of the cephalic setæ) in a sharp perforated point. Anteriorly the œsophagus is one-third as wide as the neck, excepting, of course, where it swells to receive the base of the pharynx; posteriorly it becomes one-half as wide as the neck. The cardiac collum is distinct but not conspicuous, and the cardia itself large. There is no very distinct cardiac cavity. The intestine is one-half as wide as the body. Though it often contains diatoms, I do not think the species exclusively diatomivorous. The narrow duct of the ventral gland terminates in a small ellipsoidal ampulla, which empties through the porus excretorius half-way between the base of the pharynx and the nerve-ring. The nerve-ring is nearly as wide as the œsophagus at the point encircled, and is but a trifle oblique. Near it, both behind and in front of it, I have often seen a few large and transparent cells, from some of which one or more processes passing into the adjacent tissue could be observed. Doubtless they were nerve-cells. They occur in the dorsal and lateral regions, but I do not mean by this statement to imply that they do not equally occur in the ventral region. At least as many as eight such cells may occur in the neighbourhood of the ring.

Four distinct unicellular lateral organs lying between the œsophagus and the body-wall occur near the nerve-ring, two behind and two in front of it. These organs seem to me especially interesting, and I shall describe them somewhat minutely. The two posterior of the four organs are removed from the nerve-ring a distance about equal to their own length, but they are not exactly opposite each other, the one on the right hand side being nearer the ring than that on the left hand side. The two anterior organs are even less symmetrically placed. The one nearest the ring, the right, is about as far in front of the ring as the left posterior one is behind it. The more remote anterior one, the left, is twice as far from the ring as that just described. Thus it

will be seen that these four organs are not very symmetrically placed. In other respects however they are much alike. Each is an ellipsoidal unicellular body about one third as wide as the adjacent part of the œsophagus and two thirds as wide as long. Each has one nucleolated nucleus lying in the midst of the granular contents, and each is connected from its anterior portion with the exterior by an exceedingly fine but perfectly distinct short duct which passes quite through the cuticula. The interpretation which these structures seem to call for is this: Each is a unicellular gland. I must however relate certain circumstances which cause me to be doubtful about the completeness of my observations. In the first place I have thus far observed these organs distinctly in one specimen only, a young female. In this specimen however they are so perfectly stained by carmine as to be extremely conspicuous. No other among the half dozen of this species in my Aden collection permits me to see these organs very plainly. Nevertheless I can see one or more in all of them more or less distinctly, and do not doubt the existence of at least four in each. I cannot tell why only one individual out of a half dozen of the same species treated alike should alone have taken the stain so as to show these organs. In the second place, therefore, I cannot be certain that not more than four of these organs exist in each individual; for of course the same circumstances which caused the one individual alone to so stain as to show these organs may in a like manner have caused only part of the organs in that individual itself to have taken the stain, but I do not think this very probable. After a careful search I have failed to discover more than the four, but I must add that I have made observations on species of other genera which make me believe that a series of lateral organs, each connected with the exterior, sometimes extends throughout the length of the worm. It only remains to add to this rather lengthy description of these four organs that they are quite distinct from each other.

The female sexual apparatus is asymmetrical. From the rather inconspicuous vulva the muscular vagina leads forward into the uterus, which commonly contains one to four eggs, each having a

breadth four-ninths as great as its length, this latter being twice as great as the width of the body. The reflexed ovary joins the uterus at a point as far in front of the vulva as the anus is behind it, and extends thence backwards, past the vulva, apparently to near the anus. The anterior half of the tail is concave-conoid, the diameter of the posterior cylindrical half being only one-fifth as great as the anal diameter. The terminus is distinctly swollen, and gives exit to the secretion of the rather small caudal glands.

$\frac{1{\cdot}6 \quad 7{\cdot}5 \quad 16{\cdot}9 \quad \text{-M-}^{62} \quad 91{\cdot}3}{1{\cdot}2 \quad 1{\cdot}8 \quad 2{\cdot} \quad 2{\cdot}1 \quad 1{\cdot}4}$ 3·53 mm. The tail of the male is like that of the female. The two narrowly linear, nearly straight, equal spicula, one-third as long as the tail, are almost imperceptibly arcuate in the distal half. Seen in profile, they appear to lie at an angle of 30° with the axis of the body. Their proximæ are not sufficiently contrasted with the shafts to be distinct. The two equal testicles occupy the middle half of the body. About ten hairs stand opposite the distal half of the spicula.

Hab.—This species is common on the coasts of the Northern Indian Ocean. I found it abundant in sand and among algæ on the coasts of Arabia, Ceylon, &c. Individuals of both sexes were mature in February.

O. ANGUSTATUS, Cobb*. $\frac{1{\cdot} \quad 8{\cdot}2 \quad 17{\cdot}2 \quad \text{'52'}^{35} \quad 93{\cdot}3}{\text{'8} \quad 1{\cdot}5 \quad 1{\cdot}6 \quad 1{\cdot}7 \quad \text{'8}}$ 1·77 mm. Nor is this species striated. The only conspicuous setæ are the six short ones which surround the head opposite the apex of the longest pharyngeal tooth. The anterior half of the neck is convex-conoid. The head is slightly constricted just behind the setæ, and this gives rise to a comparatively distinct labial region. Circular lateral organs probably exist opposite the base of the pharynx. This latter is nearly as wide as deep and bears three teeth, two of them only half as long as the third (the right submedian), which reaches nearly to the six lamelliform lips. These latter are of the form described for the preceding species. The œsophagus is two thirds as wide as the neck and presents at its posterior extremity a rather indistinct cardiac collum. The narrow duct of the ventral

* Cobb, "The Differentiator." Sydney, 1889.

gland terminates in a small ellipsoidal ampulla which empties through the porus excretorius a little behind the nerve-ring (9·5%). The nerve-ring is as wide as the œsophagus and oblique. The tail is concave-conoid from in front of the inconspicuous anus. The terminus is slightly swollen, having a diameter nearly one half as great as the anal diameter and giving exit to the secretion of the anal glands. The female sexual organs are double and symmetrically reflexed, occupying at least 35% of the length of the body. From the inconspicuous vulva the vagina leads to the two-parted uterus, either branch of which contains two eggs each about three fourths as wide as the body and four or five times as long as wide.

$\frac{\cdot8\ \ 8\cdot\ \ 16\cdot6\ \ M\ \ 94\cdot1}{\cdot8\ \ 1\cdot3\ \ 1\cdot4\ \ 1\cdot5\ \ \cdot8}$ 1·85 mm. Tail unlike that of the female inasmuch as it diminishes rapidly from a little in front of the anus, especially on the ventral side,—the anterior eighth being thus somewhat conoid. Then follows a slight but sudden swelling most prominent on the ventral surface. Thence to the slightly swollen terminus the tail is uniformly one third as wide as at the anus. The two equal slender spicula, almost half as long as the tail, are of nearly uniform size throughout and arcuate only in the distal third and there but slightly. Proximæ slightly swollen. Of the three pairs of papillæ one is pre-anal, opposite the arcuate portion of the spicula, and the remaining two are post-anal, the smaller being near the anus and the larger being situated in the depression in front of the swelling on the tail.

Hab.—Adults of both sexes are common in sand on the beaches of Arabia during the winter months.

O. EXILIS, Cobb.* Female unknown.

$\frac{1\cdot\ \ 7\cdot9\ \ 15\cdot2\ \ \text{-M-}\ \ 62\ \ 96\cdot9}{1\cdot\ \ 1\cdot3\ \ 1\cdot4\ \ 1\cdot4\ \ 1\cdot}$ 2·16 mm. The distinctly compressed head, succeeding to a conoid neck, is somewhat rounded in front and bears ten setæ, one dorsal, one ventral, and four double submedian. The food, passing the six triangular flap-like lips, enters a pharynx nearly as wide as deep. The two smaller pharyngeal teeth reach half way to the mouth, being only two thirds as long as the

* Cobb, "The Differentiator." Sydney, 1889.

remaining one, the left submedian. The two circular lateral organs are situated opposite the lower part of the pharynx, which they equal in width. No eye spots exist, but an abundance of brown pigment is found in the head and neck. The pharynx, two-thirds as wide as deep, bears three teeth—one, the left submedian, reaching nearly to the lips, the remaining two being only half as long. The œsophagus is swollen to receive the pharynx, then diminishes and becomes uniformly about one third as wide as the neck, until gradually swelling in the posterior fourth to more than twice that width. Cardiac collum distinct. Intestine two-thirds as wide as the body. The ventral gland, lying somewhat behind the cardiac region, empties,—by means of a long and very narrow duct and small ellipsoidal ampulla,—through a porus excretorius situated twice as far behind the base of the pharynx as the latter is behind the lips. The ventrally arcuate tail is conoid, but tapers more rapidly in the anterior than in the posterior half. It bears a number of hairs. Terminus somewhat swollen, its diameter one-fourth as great as the anal diameter. Tail glands present. The two equal, linear, nearly straight spicula scarcely exceed the anal diameter in length. Seen in profile, they seem to lie at an angle of 45° with the axis of the body. Their proximæ are scarcely enlarged. Four pairs of bristle-bearing submedian papillæ stand opposite the spicula. The anterior third of the tail is armed with three similar pairs. The two equal testicles occupy the middle third of the body.

Hab.—Beach sand ; Aden, Arabia. Mature in February.

Monhystera, Bastian.

M. mas-papillatus, n.sp. $\frac{\cdot6\ \ 8{\cdot}7\ \ 19{\cdot}2\ \ -64{\cdot}8\ \ 89^{\circ}}{1{\cdot}3\ \ 1{\cdot}9\ \ 2\ 2\ \ 2\ 6\ \ 1{\cdot}7}$ 1·59 mm. Cuticula finely striated. To the convex-conoid neck succeeds, somewhat in front of the two circular lateral organs, a distinctly expanded head, which is rounded in front, and bears six long setæ but no papillæ. These setæ are situated opposite the middle of the unarmed, gaping, cyathiform pharynx, two of them being lateral and four submedian. The lateral organs are one-third as wide as the head,

and are placed behind the pharynx at a distance from it equal to the width of the head. The whole middle third of the œsophagus is of uniform diameter, being less than half as wide as the neck; in the anterior third it expands very gradually to the pharynx; in the posterior third it expands rapidly in diameter, becoming widest (two-thirds as wide as the neck) in the seventh eighth, and diminishing thence to the distinct cardiac collum. A three-lipped cardia projects into the distinct but small cardiac cavity. The intestine is two-thirds as wide as the body. The narrow rectum is a trifle longer than the anal diameter. The nerve-ring, making an angle of 60° with the axis of the body, is wider than the œsophagus at the point encircled. Nerve-cells are abundant on both sides of the nerve-ring. I saw no ventral gland. The tail is conoid or convex-conoid from the inconspicuous anus, and contains three unicellular caudal glands placed in a longitudinal row behind the anus. Of these glands the posterior is the smallest: all empty as usual at the terminus. A vagina shorter than the diameter of the body leads forward from the inconspicuous vulva into the single uterus, which contains three or four ellipsoidal eggs one and one-half times as long as the body is wide, and half as wide as long. From the uterus the straight ovary extends forward to near the cardiac collum.

$\frac{\cdot6\ \ 9\cdot2\ \ 19\cdot2\ \ -M-\ \ 87\cdot2}{1\cdot4\ \ 1\ 9\ \ \ 2\cdot2\ \ \ 2\cdot2\ \ \ 2\cdot}$ 1·59 mm. Tail of the male like that of the female. The two equal, linear, uniformly arcuate spicula are of nearly the same size throughout, and are twisted so that when exserted they project to the right and left, or even in a posterior direction. Their proximæ are small and cephalated by constriction. Accessory pieces two, joined, exserted with the spicula, at least when the animal is killed with chemicals. The ductus ejaculatorius is longer than the œsophagus; from it the straight testicle extends forward and ends just behind the cardiac region. The species is characterised by the ventral row of six to seven very small equidistant papillæ, which exists on the male in front of the anus. The hindermost of these papillæ is opposite the proximal ends of the spicula, and the foremost is about as far from the anus as is

the end of the tail. Each papilla is the orifice of a minute one-celled gland.

Hab.—Adults of both sexes are equally common in beach sand between tide-marks on the coast of Arabia during the winter months.

HYPODONTOLAIMUS, De Man.

H. ARABICUS, n.sp. Female unknown.

$\frac{\cdot5\ \ 11{\cdot}2\ \ 18{\cdot}\ \ M\ \ 87{\cdot}4}{1{\cdot}3\ \ 2{\cdot}4\ \ 2{\cdot}5\ \ 2{\cdot}5\ \ 2{\cdot}5}$ ·9 mm. The naked cuticula bears about 450 transverse striæ, resolvable by means of the higher powers of the microscope into rows of elongated dots. The neck does not narrow very perceptibly until near the head, which is truncate and destitute of both setæ and lips. Twelve papillæ surround the mouth. I saw no lateral organs but do not assert their non-existence. There are no eye-spots. The shallow cyathiform pharynx seems to bear at its base a ventral and a dorsal tooth. The œsophagus is somewhat phalangiform, the larger and longer swelling being not that which receives the pharynx but that which forms the posterior termination. The central third of the œsophagus is only one-fourth as wide as the neck. The cardiac collum is shallow but distinct. A unicellular ventral gland nearly one-third as long as the œsophagus lies in the ventral part of the body cavity, just behind the cardiac region. It is unusually large, being one-half as wide as the intestine, and empties its product through a short duct which appears to terminate in a porus excretorius opposite to or near the cardiac collum. The nerve ring is as wide as the œsophagus at the point encircled and slightly oblique. The lateral fields are one-fourth to one-third as wide as the body. The ventrally arcuate tail is conoid to the conical terminus, which has a diameter one-fourth as great as the anal diameter, and gives exit to the secretion of three unicellular caudal glands situated opposite the anus. The two equal elongated cuneiform spicula have a length equal to that of the anal diameter. The proximæ are not cephalated. The two accessory pieces are three-fourths as long as the spicula, and are probably joined together distally. The generative apparatus extends to in front of

the middle of the body. I saw no papillæ either pre- or post-anal.

Hab.—Marine sand, Aden, Arabia.

Desmodora, De Man.

D. NUDICAPITITATA, n.sp. $\frac{\cdot2\ \ 7{\cdot}4\ \ 12{\cdot}2\ \ \text{`46·6'}^{30}\ \ 87{\cdot}}{\cdot8\ \ 1{\cdot}8\ \ 1{\cdot}9\ \ 2{\cdot}6\ \ 1{\cdot}6}$ ·9 mm. The thick and naked cuticula displays about 700 conspicuous transverse striæ resolvable with the highest power into rows of fine longitudinal markings. These striæ are not apparent on the head, but begin 0·8% of the length behind the mouth, the head thus acquiring a naked appearance, which is heightened by the absence of cephalic setæ and papillæ. The neck diminishes most rapidly in the anterior third where it is convex-conoid. The rounded naked head, bearing the lateral organs, is continuous with the neck and presents in front a small, simple, shallow depression, the pharynx, which has the form natural to three rounded lips not shutting closely together. The œsophagus is only one third as wide as the neck but expands at both ends especially the posterior where it forms a somewhat indistinct ellipsoidal or pyriform bulb as long as the neck is wide. There is a distinct cardiac collum. The intestine is not so wide as the bulb of the œsophagus. The nerve-ring is as broad as the œsophagus at the point encircled and scarcely at all oblique. Nerve-cells are abundant and conspicuous. Tail conoid to near the end, where it is half as wide as at the anus, then in the final tenth convex-conoid to a point. Caudal glands are present. The female sexual organs are double and symmetrical, occupying about 30% of the length of the body. The projecting vulva is connected by the vagina with the two branches of the uterus each of which is in turn connected with a reflexed ovary, reaching one half to two thirds the way back to the vulva and containing about eight developing ova. Eggs probably half as wide as the body, and three times as long as wide.

$\frac{\cdot2\ \ 8{\cdot}\ \ 13{\cdot}\ \ M\ \ 89{\cdot}2}{\cdot8\ \ 1{\cdot}6\ \ 1{\cdot}7\ \ 1{\cdot}8\ \ 1{\cdot}7}$ 1·mm. The tail of the male resembles that of the female in all respects. The two equal, linear, arcuate or

boomerang-shaped spicula are of uniform size throughout and their length is one and one half times as great as that of the anal diameter. The two accessory pieces, joined distally, are parallel to and one half as long as the spicula and are protruded with them to a certain extent. No ventral papillæ.

Hab.— Adults of both sexes were apparently equally common in beach sand between tide-marks, at Aden, Arabia, in February.

Spilophora, Bastian.

S. Ceylonensis, n.sp. Female unknown.

$\frac{1{\cdot}5\ \ 9{\cdot}5\ \ 18^{\cdot}\ \ M\ \ 87^{\cdot}}{1{\cdot}5\ \ 2{\cdot}4\ \ 3^{\cdot}\ \ 3{\cdot}2\ \ 2{\cdot}6}$ 1·2 mm. The cuticula bears hairs, striæ (375 in all) and dots similar tc those already described and figured by Dr. De Man for his *S. paradoxa*. To the conoid neck succeeds a truncated head whose lip region, presenting ten or twelve obscure papillæ, is set off by a constriction situated opposite the apex of the single dorsal pharyngeal tooth. From the depths of this constriction spring the four slender cephalic setæ, which are one half as long as the head is wide. I saw no lateral organs. An indistinct pharyngeal bulb receives the pharynx, which is anteriorly rather cyathiform. Posteriorly the œsophagus expands into a large elongated-pyriform double bulb nearly one third as long as the entire neck. This bulb is separated by a triple-chambered internal cavity,—containing nuclear matter that stains strongly,—into two parts, one in front of the other, each of which contains a distinct elongated chitinous structure. That portion of the œsophagus in front of the posterior bulb is not of uniform diameter but averages one fourth as wide as the neck. The nerve-ring is nearly as wide as the œsophagus at the point encircled and is not at all oblique. The intestine is attached to the centre of the rather flattened posterior surface of the cardiac bulb and is at first very narrow. Its rather thin walls are composed of cells containing coarse granules of a brownish colour. These cells are of such a size that three build the circumference of the intestine. I discovered nothing concerning the ventral gland. The tail is nearly conical, being in reality slightly concave. The two linear spicula are

equal and arcuate. They are one and one half times as long as the anal diameter and not of uniform breadth, presenting noticeable irregularities. Their proximal ends are not cephaloid. The two lamelliform accessory pieces are two thirds as long as the spicula. The single testicle, one half as wide as the body, and hardly as long as the œsophagus, is directed forwards, only its free extremity being reflexed. In its anterior fourth are found the mother-cells of the spermatozoa. Their diameter nearly equals the width of two of the striæ of the cuticula. These mother-cells are granular and stain strongly. In the succeeding fourth of the testicle the mother-cells give rise to the true spermatozoa which fill the posterior half of the testicle. These are spherical cells whose diameter is slightly greater than the width of one of the striæ, and whose nuclei only can be stained, at least with carmine. It will be seen that this organ has a double function. It is at once testicle and vas-deferens. The ductus ejaculatorius is composed of two rows of cells, the first ten or twelve pairs being larger than the others and of a different structure.

Hab.—Found among algæ and in the sand at their roots on the coasts of Arabia and Ceylon. The males were mature in February.